OBSERVATIONS ON THE LIFE HISTORY OF *ACANTHOPSYCHE ATRA* L. (LEP.: PSYCHIDAE)

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Abstract

Observations on rearing *Acanthopsyche atra* L. (Lep.: Psychidae) from ova, and of adult behaviour, are presented. The species exhibits strong protogyny, a behavioural mechanism believed to prevent inbreeding, as might be expected in a species with poor ability to disperse. The moth is considered to be overlooked rather than a genuine rarity. The cases, and male and female adults are illustrated in colour.

Introduction

The life histories of the British species in the family Psychidae, with a few exceptions such as *Pachythelia villosella* (Ochs.) (Heath, 1946), are relatively poorly understood. However, what we do know suggests a diverse range of behaviours and rather plastic morphology between species contributing to their reproductive strategies, in comparison with other families of moth in Britain. Scanning the text of Volume 2 of *The Moths and Butterflies of Great Britain and Ireland* (Hättenschwiler, 1985) we see that the females of most, but not all, species have abandoned wings and must rely on different mechanisms for dispersal of their progeny.

In this vein, perhaps the most bizarre account is that of *Acanthopsyche atra* L., brought to our attention in British literature by Jacobs (1958) and Hoffmeyer (1970), both reporting the same observations made in the 1950s by Hoffmeyer's Danish colleague, P.L. Joergensen. In summary, wingless females of this species leave their cases a few days after mating; when such females were fed to captive robins (*Erithacus rubecula*), viable ova survived the birds' digestive system and larvae hatched from the faeces a fortnight later. Whilst not many hatched given the number of females ingested, the observation offers the possibility that birds are involved in dispersal. It would appear that part of the female's strategy is to get eaten; this is a peculiar reversal of the dominant strategy amongst Lepidoptera which have spent millions of years of their evolutionary history honing their morphological and behavioural avoidance mechanisms to avian predators.

I have spent some time on the Dorset heaths trying to find *A. atra*, so was pleased to come across two cases of this apparently very local moth on Upton Heath, Dorset (O.S. grid reference SY 9893, VC 9) on 6 June 2003. Both were fixed low down, no more than 10cm from the ground, one on a heather stem, another on a wooden post. By chance the neighbouring post had a case of *P. villosella* attached somewhat higher up (c. 50cm). The size difference between cases of the two species was immediately apparent, and those of *A. atra* were adorned with shorter and more uniformly sized fragments of heathers and grasses. The size range of cases of the species is given in Hättenschwiler (*loc. cit.*).

On closer examination I noticed that one of the *A. atra* cases was empty, but the other appeared to have a female within and with a hand lens I thought I could make out that this was her posterior end. I did not realise the significance of these observations at the time.

The two cases were amongst humid heath, in an area where cross-leaved heath *Erica tetralix* and purple moor-grass *Molinia caerulea* were co-dominant and heather *Calluna vulgaris*, was frequent. Barrett (1895) suggests that the moth is usually confined to sandy locations; whilst the underlying minerals of Upton Heath are sands and clays, there was no bare sand in the vicinity of where I had found the *A. atra* cases, although there were areas of bare peaty soil which had been poached by grazing animals. I suggest that the moth has little habitat preference other than for dry or humid heathland.

Notes on rearing

I kept the female in her case in a container for over three weeks and was then surprised to observe that many larvae in tiny cases were crawling over the old case. I estimated that there were probably about a hundred of them. At no time could I see that the female had laid eggs, and I assume the larvae had hatched within her body.

I set up a large plant pot containing a living plant of heather and bristle bent grass *Agrostis curtisii* and placed the larvae on the plants, covering the whole pot in a fine mesh sleeve. I kept the plants watered regularly.

Between July and September, the young larvae and their cases were rarely seen and must have been at the base of the plants. Occasionally I saw a larva eating green grass and when I introduced fresh leaves of deciduous shrubs such as plum *Prunus domestica*, and birch *Betula pendula* these were nibbled. However, once these leaves had wilted and changed colour they were eaten more readily, usually from the edge of the leaf. The cases remained small throughout the summer, and by mid-autumn had reached no more than 1 cm in length.

Over the winter it was hard to find any case and it was not until the end of April that cases were again visible, larvae crawling to the tops of stems briefly before disappearing again. It appeared that around 40 cases had survived their first year.

Although the heather and grass plants had survived and may have been eaten, I regularly introduced fresh plum leaves and observed that once wilted, these were devoured. Feeding was apparent between April and October during which time the cases were increasing in size and being adorned with fragments of heather and other tiny twigs. No plum leaf litter was incorporated into the case. By mid-autumn it was reasonably clear which cases would produce male and female moths; those of the males had extended the distal end of the case into an opaque dirty white silk tube, largely unadorned (Figures 1 & 2). Throughout summer and autumn, cases were rarely obvious, the larvae spending much of their time hiding low down amongst the leaf litter and near the base of the plants.

Cases were fixed very low down amongst vegetation during the second winter and were hardly visible at all. By early April, cases began to reappear and had moved up

the standing vegetation and sleeve to between 5 cm and 15 cm to fix for pupation. I did not observe any feeding during this time, nor did I see any further extension of silk tubing to the cases of males. In total just under thirty larvae of the forty which had survived the previous winter had fixed. I put all these cases into a plastic container to await emergence.

Observations on the adults

Adults began to emerge in early May and I was surprised that for the first two weeks it was only females that appeared. Actually, emergence was not obvious. From time to time a pale brown sclerotised structure appeared at the open end of several cases, and a paler structure at the end of a few, but any disturbance, such as taking the lid off the container, caused the adults to retreat into their cases.

Figure 1. Male case of *Acanthopsyche atra* (L.)

After only a day, one unmated female wriggled out of her case and lay on the floor of the container (Figure 3). On close observation I could see that the adult had no appendages at all, and no scales. The sclerotised structure I had observed emerging from the distal end of the case was the head and thorax, and the paler structure the genitalia, which were the same colour as the abdomen. The adult female looked and behaved just like a fly maggot; she was creamy in colour and moved only slowly by a weak peristalsis from anterior to posterior. Perhaps this would explain why

Joergensen had said that the females dropped to the ground where they were easily discovered by birds. The behaviour and colour could not offer any camouflage against the darkness of peaty soils.

I thought for a while that none of the males might emerge so on 9 May I took a number of females to Upton Heath to see if they would assemble males. The weather was fine and sunny but with a cool breeze, and I was on the heath between 12:45 and 13:45 BST. I placed the box in sunshine at the top of a heather bush and carefully removed the lid. After a few minutes some females appeared at the open end of the cases and very shortly afterwards males arrived. In any one area only one or two males were assembled, but repeating the assembling method across various parts of the heath almost always produced at least another male. This suggested that males were at low density but were widespread on the heath.

Figure 2. Female case of *Acanthopsyche atra* (L.)

Between 13.45 and 14.45 I also spent a short while on both Canford Heath in Poole and Winfrith Heath near Wool (both in VC 9) and was able to assemble a male at each, demonstrating the presence of the species on these heaths.

I became intrigued by how the male would mate with the female, as it was the head and thorax of the female that I saw at the open end of most cases. It appears that the male has an extraordinary elastic body and musculature. I observed he was able to extend his abdomen several times its resting length, and insert the full length

of this long body into the female's case, where presumably mating took place. I also noted that the male did not have to extend his abdomen so far to mate with those females presenting genitalia at the open end. Sadler (1969) noted that it was the 'brown shiny head' of the adult female of *P. villosella* that was visible at the open end of the case, and Hoffmeyer (*loc. cit.*) refers to a photograph of a male of *P. villosella* post-copulation, commenting on how 'much elongated' was his abdomen. This suggests a very similar mating technique in the two species.

It was not until 14 days after the first female had emerged, and well after the majority had done so, that the first male appeared from my cases in captivity (Figure 4). In the next 10 days a number of males emerged, usually some time during the main part of the day, though I observed males emerging at least twice in the early evening. Most males emerged whilst I was at work and were severely damaged by the time I saw them. They seemed to spend much of their time flying in the container.

Figure 3. Adult female *Acanthopsyche atra* (L.) showing the peristaltic contraction part way along the abdomen.

This delayed emergence of the male is believed to be an example of protogyny, a behavioural phenomenon known in the entomological world where males emerge later than females helping to minimise the risk of inbreeding (in protandry, males emerge before females). Protogyny could be advantageous to *A. atra*, a species which would appear to have poor powers of dispersal in space (save via possible predation of the adult female) and where the likelihood of mating with siblings would be enhanced without delayed emergence of one or other sex.

Figure 4. Adult male. *Acanthopsyche atra* (L.).

I kept female cases separately, once mated, and noted that the adult females within most, but not all of the containers, emerged from their cases and dropped to the floor of the container where they continued their peristaltic contractions until they died.

The time taken for females to wriggle free from their cases after mating ranged from a couple of hours to about three days. At no time did I observe any oviposition from these 'free-living' females and I concluded that the ova must have remained within the abdomens, given their size. I am puzzled, therefore, by the statement in Hättenschwiler (*loc. cit.*) that ova are laid in the pupal skin. This cannot always be the situation as the observations with the robin have demonstrated.

I examined the few cases which still contained females and noted that they were exactly as the one I had originally found on Upton Heath two years earlier. I could see their posterior ends. It occurred to me that the reason that these females remained within their cases was that they were genuinely trapped, and probably deliberately so. I only ever observed the peristalsis of 'free-living' females in one direction (head to tail) and if this were true of those facing the 'wrong way' in their cases, then I do not believe they could get out. Given their relatively weak movement I did not think it plausible that a female could turn round in her case having emerged, though I suppose this a possibility. I also consider that the female is trapped there by design;

her progeny get the chance to develop in the vicinity of where their mother lived to adulthood, and more immediately, the young larvae can obtain their first meal and case construction materials within the protective jacket of her old case.

My last curiosity with this species left me wanting to repeat the whole rearing exercise. I kept all 'free-living' females and encased females separately, in the hope that I could observe emergence of the young larvae. I had no success at all with the 'free-living' females, but plenty of larvae appeared from those trapped in their cases. I did not observe whether 'trapped' females laid eggs in the pupal skin, or whether they remained within the abdomen. It could not be that ova within 'free-living' females must pass through the gut of an animal to have any chance of viability, could it? Perhaps it is more likely that I had not got the environmental conditions right, since these females either desiccated or went mouldy in the end, but the possibility remains.

Although the evidence that birds are involved in dispersal of this moth is intriguing, I do wonder how frequent predation would be by avian predators in the wild, and whether other predators may be involved. Lowland heathlands in Dorset support a range of insectivorous birds. Perhaps the most frequent of those likely to forage through the dense vegetation would be Wren *Troglodytes troglodytes* and Dunnock *Prunella modularis*, but others could include Stonechat *Saxicola torquata* and Dartford Warbler *Sylvia undata*. However, densities of breeding birds on lowland heathland are generally low, perhaps a few pairs per hectare. Also, once the female has wriggled free of her case she is most likely to fall into a deep jumble of leaf litter and woody material that characterises the understorey of mature heaths in Dorset. Thus I think the chances of *A. atra* females being eaten would be low, although I accept the dispersal strategy would still work even if predation were an infrequent event. In this county it may be more likely that females are taken by other predators, such as reptiles or possibly small mammals. The density of reptiles on the Dorset heaths is very high, in the hundreds or even thousands per hectare, particularly of Slow-worm *Anguila fragilis* and Common Lizard *Lacerta vivipara*. As these animals would be regularly foraging amongst the heather plants, and the size of prey would be ideal for them, I would suggest they could be predating the females more frequently than are birds. As to whether ova can survive passage through the reptilian gut, I hope to be able to answer this question in due course.

I thus believe there are two dispersal strategies in *A. atra*. Which one is taken up is likely to depend on which way round the 'female' larva pupated in the case (I assume the larva, which has thoracic legs, is capable of turning around within the case). Once hatched, the female either wriggles free of her case and tries to get eaten to aid dispersal of her progeny, or she stays put (she has no option but to do so) and her progeny have a chance to develop in the area in which she managed to survive.

As I write, young cases of the next generation have more or less disappeared for the winter. It will be spring 2007 before I get another chance to observe the extraordinary behaviours of this moth and to experiment with a few predators!

Comments on conservation

It is clear that *A. atra* is a moth of retiring habit, spending most of its life out of view deep amongst heather plants. The larva is principally a detritivore, though some living plant material is also eaten, so there is almost no evidence of feeding pattern. Only when the larva fixes to pupate does the case become apparent, but usually it does so relatively low to the ground where it can easily be overlooked. Also the adult is rarely seen. Given the widespread but scattered distribution of the moth from the lowland heathlands of southern England to the moorlands of Wales and Scotland, it seems that *A. atra* is far more likely to be an overlooked species than it is to be a genuinely rare moth.

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